OCCURRENCE OF *CAMPYLOBACTER* SPECIES, *SALMONELLA* SPECIES AND GENERIC *ESCHERICHIA COLI* IN MEAT PRODUCTS FROM RETAIL OUTLETS IN THE FARGO METROPOLITAN AREA

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ABSTRACT

Foodborne illnesses are a substantial health burden in the United States, with Campylobacter, *pathogenic* Escherichia coli *and* Salmonella *reported among the major bacterial foodborne pathogens. These organisms are often present in fresh meat and poultry with regional differences in incidence. The objectives of this study were (1) to determine occurrence of foodborne pathogens* Campylobacter *and* Salmonella *as well as generic* Escherichia coli *in raw meats sold in retail grocery stores in the Fargo metropolitan area of North Dakota in the Midwestern United States; and (2) to correlate observed prevalence with the product type and retail store. A total of 456 fresh raw meats (turkey, chicken, pork, beef) were purchased and tested for microbial contamination. Overall, 341 (75%) of the samples were contaminated with generic* E. coli *(*n = *316, 72%),* Campylobacter *(*n = *12, 2.6%) and* Salmonella *(*n = *13, 2.9%). The meats differed significantly (*$P < 0.0001$*) in contamination rate with* Campylobacter *and* Salmonella, *but not among the five stores.*

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PRACTICAL APPLICATIONS

The data indicate that meat products, particularly poultry (chicken and turkey), purchased from retail stores in the Fargo metropolitan area may occasionally be contaminated with *Campylobacter* and *Salmonella*. This signifies the importance of sustained surveillance of foodborne pathogens in retail meats. In addition, the data suggest that microbial contamination on raw retail meats purchased in the metropolitan area of a rural agricultural state are not higher than those reported for larger urban locales.

INTRODUCTION

As a result of fecal contamination during processing of the carcass and handling of raw products, poultry and retail meats are often contaminated with gastrointestinal flora, which may be possible sources of foodborne pathogens. Foodborne illnesses are a substantial health burden in the United States (Allos and *et al.* 2004), with an estimated 76 million persons experiencing foodborne illnesses each year (Mead *et al.* 1999). *Campylobacter*, pathogenic *Escherichia coli* and *Salmonella* are among the major bacterial foodborne pathogens both in the United States and worldwide. Additionally, commensal organisms such as generic *E. coli* can play a significant role in the transfer of antimicrobial resistance to other intestinal organisms, some of them pathogenic (Schroeder *et al.* 2003; Dunowska *et al.* 2006). In 1996, the U.S. Foodborne Diseases Active Surveillance Network (FoodNet) of the U.S. Centers for Disease Control and Prevention (CDC)'s Emerging Infections Program initiated surveillance of 10 U.S. sites for diseases caused by enteric pathogens transmitted commonly through food. The 2005 FoodNet data (CDC 2005) indicated significant declines in infections caused by *Campylobacter*, *Listeria*, *Salmonella*, Shiga toxin-producing *E. coli* O157 (STEC O157), *Shigella* and *Yersinia*, thus approaching the national health objectives for reducing human foodborne illnesses (CDC 2006). The decline in *Salmonella* incidence, in particular, was reported to be modest compared with those of other foodborne bacterial pathogens (CDC 2006). In 2005, a total of 16,614 laboratory-confirmed cases of infections in FoodNet surveillance areas were identified, and overall incidence per 100,000 population was determined for *Salmonella* (14.550) and *Campylobacter* (12.72) (CDC 2006).

Testing by the United States Department of Agriculture (USDA), Food Safety and Inspection Service (FSIS) at slaughter and processing plants demonstrated declines in *Salmonella* contamination of ground beef since 1998 (USDA-FSIS 2006a). However, the FSIS recently announced a sustained increase in chicken-broiler carcasses testing positive for *Salmonella* during

2002–2005 and subsequently launched an initiative to reduce *Salmonella* in raw meat and poultry products (USDA-FSIS 2006a,b). Additionally, studies worldwide have shown that *Campylobacter*, *Salmonella* and generic *E. coli* are often present in fresh meat and poultry (Todd 1997) with regional differences in incidence of certain bacterial foodborne diseases documented (CDC 1998). However, few studies (Chen *et al.* 2004; Zhao *et al.* 2001) estimate the prevalence of multiple foodborne pathogens in retail meats in primarily rural areas of the United States. None have specifically addressed the urban areas of North Dakota. The objectives of this study were to determine the occurrence of *Campylobacter*, *Salmonella* and generic *E. coli* in raw meat products from retail outlets in Fargo, an urban city in North Dakota, an agricultural state in the Midwestern United States and to compare contamination rates among meat types and representative retail stores.

MATERIALS AND METHODS

Study Area and Stores Sampled

The study was conducted in Fargo metropolitan area, North Dakota, with a total population of 121,564 (Fargo 90,056; West Fargo 21,508) (United States Census Bureau, 2000). The estimated average annual per capita income for the study area was U.S.$21,101 (the average for North Dakota was U.S.$17,769 compared with U.S.$28,659 for the greater Washington, DC area. The average annual per capita income for the United States was U.S.$21,587 (United States Census Bureau 2000). Five out of a total of 15 area grocery stores were sampled: Store A (1 out of 2), store B (1 out of 6), store C (1 out of 1), store D (1 out of 5) and store E (1 out of 1). Store A is regional and gets all its meat products from a regional source. Store B is regional and obtains its chicken, pork and turkey from a regional source while the beef is obtained mostly regionally (from the Midwest) and sometimes nationally. The average number of customers served daily, based on store managers' estimates, was as follows: Store A (approximately 2,500), store B (15,000), store C (6,500 to >10,000) and store D (500–15,000). Store E was the only one of a kind in the area selling specialty meats and served approximately 350 people per day (personal communication with store managers). Store C is a national chain; however, it obtains its meat products from a regional source. Store D is also national but receives its meat products from the upper Midwest. Store E purchases its chicken from a regional source and beef and pork from a national source.

Sampling Procedure

Fresh raw meat products were purchased from five retail stores in the Fargo metropolitan area during a 12-week period (July 11, 2005 to October 3,

2005). Three stores were visited each week until all the stores had been visited a total of five times. The stores were sampled on different days of the week during subsequent sampling times in order to minimize systematic bias associated with a particular day of the week. On each visit to a store, an average of 18 (range 11–23) fresh raw samples of all meat types (turkey, chicken, pork and beef) and different meat products were obtained. Turkey products sampled included: ground breast, breast, breast cutlets, breast tenderloin, drumstick and thigh. Chicken products comprised whole, quarter, breast, drumstick, thigh, wing and kebab; pork products included ground, chops, steak, ribs, neck bones, roast and stew; beef products consisted of ground beef-store brand, steak, stew, chuck, roast, ribs, round, loin and kebab. Where available, different brands were selected including in-store packaged products. All products were raw and unfrozen. Samples were immediately transported to the laboratory on ice and processed within 1 h of purchase.

Sample Processing and Bacteriological Isolations

Samples were aseptically placed in a plastic WhirlPak bag (Nasco, Fort Atkinson, WI) with 200–400 mL of buffered peptone water, depending on the size of the meat sample. Approximately 200 mL and 400 mL of buffered peptone water was added to any meat sample that was $\leq$1 lb and >1 lb, respectively. The bags were shaken manually for 3 min and left on ice for 20 min. All samples were subjected to an enrichment procedure. For *Campylobacter*, a 20-mL portion of meat rinse was mixed with the same volume of double-concentrated Bolton broth and incubated (42C for 24 h) under microaerophilic conditions (AnaeroPack System, Mitsubishi Gas Chemical America, Inc., New York, NY). The overnight enrichment broth was transferred onto blood-free *Campylobacter* selective agar (CCDA; Oxoid Ltd., Basingstoke, Hampshire, U.K.) plates with a sterile cotton swab and plates were incubated (42C for 48 h) under a microaerophilic atmosphere. Typical *Campylobacter* colonies (small, grey and drop-like or small, and shiny or slimy) were subcultured onto fresh media (CCDA) for presumptive identification of *Campylobacter* by Gram staining and oxidase test. Presumptive *Campylobacter* isolates were sent to the National Animal Disease Center (NADC, Ames, IA) for speciation.

For both *E. coli* and *Salmonella*, the buffered peptone water rinse solution (20 mL) was mixed with the same volume of double-concentrated lactose broth and enriched overnight at 35C. To culture generic *E. coli*, the enrichment broth was streaked onto MacConkey agar plates and incubated (35C for 24 h) Following incubation, lactose-positive colonies were streaked onto Levine eosin methylene blue agar (EMB; Difco Laboratories, Becton, Dickinson and Company, Sparks, MD) and incubated (35C for 24 h). Typical *E. coli* colonies

were green and shiny with dark or purple centers. Each isolate was cultured on MacConkey sorbital agar (SMAC; Difco), and one sorbitol fermentation-negative colony was tested for the presence of the 0157 antigen using the *RIM E. coli* 0157:H7 latex agglutination kit (Remel, Lenexa, KS). For *Salmonella*, 1.0 mL of the lactose enrichment broth was transferred into 9.0 mL of tetrathionate broth and incubated (42C for 24 h). The broth culture was then streaked onto XLT4 agar plates and incubated (24 h at 37C). Suspect colonies (yellow with black centers) were stabbed in triple sugar iron (TSI) agar slants and incubated (37C for 24 h). Presumptive *Salmonella* isolates, which formed red slants with black butts, were sent for serotyping to the U.S. National Veterinary Services Laboratories (NVSL, Ames, IA).

Data Analysis

Association of recovery rates for each of the organisms from the different meat types and stores was computed using SAS software (SAS Institute, Cary, NC). The relative percentages of positive isolates out of the total number of samples tested were computed and compared using Pearson chi-square analysis with the level of significance set at $P \leq 0.05$. In addition, Fishers Exact test was performed to determine differences in recovery rates of organisms between meat types and within stores.

RESULTS

Overall Prevalence

The number and percentage of the total raw meat samples ($n = 456$) purchased were as follows: turkey ($n = 87$, 19.1%), chicken ($n = 123$, 27.0%), pork ($n = 113$, 24.8%) and beef ($n = 133$, 29.2%). The distribution of samples that tested positive for *Campylobacter*, *Salmonella* and generic *E. coli* by meat type and meat part is summarized in Tables 1–4. In total, 75% (341 of 456) of all the samples purchased were contaminated with at least one microorganism; 5.5% (25 of 456) of samples were contaminated with *Campylobacter* and *Salmonella* (Table 5); 72% (316 of 456) were contaminated with generic *E. coli* (Table 6).

Prevalence by Meat Product

For *Campylobacter*, the prevalence by meat type was as follows: turkey (1.1%, 1/87), chicken (9%, 11/123), pork (0%, 0/113) and beef (0%, 0/133) (Tables 1–4). For *Salmonella* the prevalence rate was as follows: turkey (9.2% (8/87), chicken (4%, 5/123), pork (0%, 0/113) and beef (0%, 0/133) (Tables 1–

TABLE 1.
NUMBER AND PERCENTAGE OF RETAIL TURKEY MEATS THAT TESTED POSITIVE FOR *CAMPYLOBACTER*, *SALMONELLA* AND GENERIC *ESCHERICHIA COLI* BY MEAT PART IN THE FARGO, NORTH DAKOTA METROPOLITAN AREA, 2005 ($n = 87$)

Meat part	*Campylobacter*	*Salmonella*	*Escherichia coli*	Total	
Ground turkey (16)	0	5	14	19	19/87 (22%)
Ground turkey breast (15)	0	1	12	13	13/87 (15%)
Turkey breast (8)	0	1	6	7	7/87 (8%)
Turkey breast cutlets (7)	0	0	6	6	6/87 (7%)
Turkey breast tenderloin (6)	0	0	4	4	4/87 (5%)
Turkey drumstick (20)	0	1	9	10	10/87 (12%)
Turkey thigh (15)	1	0	11	12	12/87 (14 %)
Total	1 1/87 (1.1)	8 8/87 (9.2%)	62 62/87 (71%)	71	71/87 (82%)

TABLE 2.
NUMBER AND PERCENTAGE OF RETAIL CHICKENS THAT TESTED POSITIVE FOR *CAMPYLOBACTER*, *SALMONELLA* AND GENERIC *ESCHERICHIA COLI* BY MEAT PART IN THE FARGO, NORTH DAKOTA METROPOLITAN AREA, 2005 ($n = 123$)

Meat part	*Campylobacter*	*Salmonella*	*Escherichia coli*	Total	
Chicken drumstick (20)	0	1	13	14	14/123 (11%)
Chicken breast (28)	1	1	17	19	19/123 (15%)
Chicken kebab (4)	0	0	3	3	3/123 (2.4%)
Chicken leg quarter (2)	0	0	2	2	2/123 (2%)
Chicken thigh (20)	3	1	13	17	17/123 (14%)
Chicken wings (20)	3	0	10	13	13/123 (11%)
Whole chicken (29)	4	2	25	31	31/123 (25%)
Total	11 11/123 (9%)	5 5/123 (4.1%)	83 83/123 (68%)	99	99/123 (81%)

4). For generic *E. coli* the prevalence was as follows: turkey (71%, 62/87), chicken (68%, 83/123), pork (70%, 79/113) and beef (69%, 92/133) (Tables 1–4). There was a statistically significant difference ($P < 0.0001$) between turkey meat and chicken in the level of contamination with *Campylobacter* and *Salmonella*, with more *Campylobacter* recovered from chicken (9%) than turkey (1%), and more *Salmonella* (9%) recovered from turkey than chicken (4%). None of the beef or pork samples were contaminated with either *Campylobacter* or *Salmonella*, precluding valid statistical comparisons for these two meat types. There was no significant difference ($P = 0.8866$) in the level of contamination of the four different meat types with generic *E. coli.* Among the turkey products *Campylobacter* was recovered only from one turkey thigh

TABLE 3.
NUMBER AND PERCENTAGE OF RETAIL PORK SAMPLES THAT TESTED POSITIVE FOR *CAMPYLOBACTER*, *SALMONELLA* AND GENERIC *ESCHERICHIA COLI* BY MEAT PART IN THE FARGO, NORTH DAKOTA METROPOLITAN AREA, 2005 (n = 113)

Meat part	*Campylobacter*	*Salmonella*	*Escherichia coli*	Total	
Ground pork (21) (*store brand*)	0	0	14	14	14/113 (12%)
Pork chops (25)	0	0	18	18	18/113 (16%)
Pork neck bones (10)	0	0	7	7	7/113 (6%)
Pork ribs (25)	0	0	17	17	17/113 (15%)
Pork roast (20)	0	0	15	15	15/113 (13%)
Pork steak (10)	0	0	6	6	6/113 (5%)
Pork stew (2)	0	0	2	2	2/113 (2%)
Total	0 0/113 (0%)	0 0/113 (0%)	79 79/113 (70%)	79	79/113 (70%)

TABLE 4.
NUMBER AND PERCENTAGE OF RETAIL BEEF SAMPLES THAT TESTED POSITIVE FOR *CAMPYLOBACTER*, *SALMONELLA* AND GENERIC *ESCHERICHIA COLI* BY MEAT TYPE AND PART IN THE FARGO, NORTH DAKOTA METROPOLITAN AREA, 2005 (n = 133)

Meat type	*Campylobacter*	*Salmonella*	*Escherichia coli*	Total	
Ground beef (27) (*store brand*)	0	0	19	19	19/133 (14%)
Beef chuck steak (7)	0	0	4	4	4/133 (3%)
Beef kebab (5)	0	0	4	4	4/133 (3%)
Beef rib eye steak (3)	0	0	2	2	1/133 (1%)
Beef ribs (11)	0	0	7	7	7/133 (5%)
Beef round roast (22)	0	0	19	19	19/133 (14%)
Beef round steak (13)	0	0	7	7	7/133 (5%)
Beef sirloin steak (22)	0	0	15	15	15/133 (11%)
Beef stew (23)	0	0	15	15	15/133 (11%)
Total	0 0/133(0 %)	0 0/133 (0%)	92 92/133 (69%)	92	92/133 (69%)

(1/15, 7%), while most *Salmonella* (5/16, 31%) was recovered from ground turkey (Table 1). The other turkey parts where *Salmonella* was recovered included turkey breast (1/8, 13%), ground turkey breast (1/15, 7%) and turkey drumsticks (1/20, 5%) (Table 1). For chicken products most *Campylobacter* (4/11, 36%), *Salmonella* (2/5, 40%) and generic *E. coli* (25/83, 30%) were recovered from whole chicken with specific whole chicken recovery rates of 14% (4/29), 7% (2/29) and 86% (25/29), for these three microbes, respectively (Table 2).

TABLE 5.
NUMBER AND PERCENTAGE OF RETAIL MEAT SAMPLES THAT TESTED POSITIVE FOR *CAMPYLOBACTER* AND *SALMONELLA* BY STORE AND MEAT TYPE IN THE FARGO, NORTH DAKOTA METROPOLITAN AREA, 2005 ($n = 456$)

Store/meat type	*Campylobacter*	*Salmonella*	Total
Store A ($n = 97$)			
Whole chicken	1	0	1
Ground turkey	0	1	1
Turkey breast	0	1	1
Total	1	2	3
	1/97 (1%)	2/97 (2%)	3/97 (3%)
Store B ($n = 108$)			
Turkey drumstick	0	1	1
Chicken drumstick	0	1	1
Chicken thigh	1	0	1
Whole chicken	1	2	3
Total	2	4	6
	2/108 (2%)	4/108 (4%)	6/108 (6%)
Store C ($n = 95$)			
Chicken breast	1	0	1
Chicken thigh	1	0	1
Chicken wings	2	0	2
Whole chicken	1	0	1
Ground turkey breast	0	1	1
Total	5	1	6
	5/95 (5.3%)	1/95 (1.1%)	6/95 (6%)
Store D ($n = 93$)			
Ground turkey	0	4	4
Chicken thigh	1	1	2
Whole chicken	1	0	1
Chicken wings	1	0	1
Turkey thigh	1	0	1
Total	4	5	9
	4/93 (4.3%)	5/93 (5.4%)	9/93 (10%)
Store E ($n = 63$)			
Chicken breast	0	1	1
Total	0	1	1
	0/63 (0%)	1/63 (1.6%)	1/63 (1.6%)
Grand total ($n = 456$)	12	13	25
	12/456 (2.6%)	13/456 (2.9%)	25/456 (5.5%)

For pork products no *Campylobacter* or *Salmonella* was recovered. Most generic *E. coli* (18/25, 72%) was recovered from pork chops followed by pork ribs (17/25, 68%) and ground pork (14/21, 67%) (Table 3). For beef products no *Campylobacter* or *Salmonella* was recovered; generic *E. coli* was recovered from ground beef (19/27, 71%), sirloin steak (15/22, 68%), roast (15/22, 68%) and stew (15/23, 65%) (Table 4).

TABLE 6.
NUMBER AND PERCENTAGE OF RETAIL MEAT SAMPLES THAT TESTED POSITIVE FOR GENERIC *ESCHERICHIA COLI* BY MEAT TYPE AND BY STORE IN THE FARGO, NORTH DAKOTA METROPOLITAN AREA, 2005 ($n = 456$)

Meat type	Store A	Store B	Store C	Store D	Store E	Total	% Meat type
Turkey ($n = 87$)							
Ground turkey (16)	5	4	3	2	0	14	
Ground turkey breast (15)	1	3	4	4	0	12	
Turkey breast (8)	4	2	0	0	0	6	
Turkey breast cutlets (7)	0	1	4	1	0	6	
Turkey breast tenderloin (6)	0	3	0	1	0	4	
Turkey drumstick (20)	1	3	2	3	0	9	
Turkey thigh (15)	4	2	0	5	0	11	
Total	15	18	13	16	0	62	62/87 (71%)
Chicken ($n = 123$)							
Chicken drumstick (20)	5	4	1	3	0	13	
Chicken breast (28)	3	5	3	1	5	17	
Chicken kebab (4)	0	0	0	0	3	3	
Chicken leg quarter (2)	0	0	1	1	0	2	
Chicken thigh (20)	4	3	2	4	0	13	
Chicken wings (20)	5	2	1	2	0	10	
Whole chicken (29)	4	9	4	4	4	25	
Total	21	23	12	15	12	83	83/133 (68%)
Pork ($n = 113$)							
Ground pork (21)	2	3	5	3	1	14	
Pork chops (25)	4	4	3	3	4	18	
Pork neck bones (10)	3	0	4	0	0	7	
Pork ribs (25)	3	4	4	2	4	17	
Pork roast (20)	2	4	0	4	5	15	
Pork steak (10)	0	1	3	0	2	6	
Pork stew (2)	0	0	2	0	0	2	
Total	14	16	21	12	16	79	79/113 (70%)
Beef ($n = 133$)							
Ground beef (27)	3	3	4	4	5	19	
Beef chuck (7)	3	1	0	0	0	4	
Beef kebab (5)	0	0	0	0	4	4	
Beef rib eye steak (3)	0	0	0	0	2	2	
Beef ribs (11)	0	2	2	0	3	7	
Beef round roast (22)	5	2	4	4	4	19	
Beef round steak (13)	1	2	1	3	0	7	
Beef sirloin steak (22)	3	1	4	2	5	15	
Beef stew (23)	3	3	4	2	3	15	
Total	18	14	19	15	26	92	92/133 (69%)
Grand total ($n = 456$)	68	71	65	58	54	316	316/456 (72%)
	68/97 (70%)	71/108 (66%)	65/95 (68%)	58/93 (62%)	54/63 (86%)		

Prevalence by Meat Brand

All beef and pork products were store brands, precluding statistical comparisons of contamination rates between the brands within the meat type. Turkey meat products were distributed among brands A (35/87, 40%), B (28/87, 32%) and unknown (24/87, 28%). Overall, there was no significant difference in *Campylobacter*, *Salmonella* or generic *E. coli* contamination rates for turkey products ($P > 0.05$) between the brands. Chicken products were distributed among brands A (53/123, 43%), B (17/123, 14%), C (7/123, 5.6%), D (6/123, 4.9%) and unknown (40/123, 32.5%). Overall, there was no significant difference in *Campylobacter*, *Salmonella* or generic *E. coli* contamination rates for chicken between the brands.

Prevalence by Store

Overall, there was a significant difference in recovery of generic *E. coli* ($P = 0.0291$), but not *Campylobacter* ($P = 0.073$) and *Salmonella* ($P = 0.5955$), among the five stores. Store E had significantly lower ($P < 0.05$) contamination rates for generic *E. coli* than the other four stores (A, B, C and D). Overall, store E had lower contamination rates (0%) for *Campylobacter* and store C (1.1%) for *Salmonella* (Table 5). Stores C and D had the highest contamination rates for *Campylobacter* and for *Salmonella*, respectively (Table 5), while store E had the highest contamination rate (54/63, 86%) for generic *E. coli* compared with the other stores (Table 6). Between stores, there was a significant difference in contamination rates of beef ($P = 0.0474$) and chicken ($P = 0.0221$), but not pork ($P = 0.0956$) and turkey ($P = 0.9397$) with generic *E. coli*. Also among stores, there was a significant difference in contamination rates of chicken ($P = 0.0497$) with *Campylobacter*, with the highest recovery obtained from store C followed by D, B and A (Table 1). Within store C, chicken is the only meat type that had *Campylobacter*, and there was a significant difference in recovery of *E. coli* ($P = 0.0353$) between the meat types but not *Salmonella.* Within store D, there was a significant difference in recovery of only *Salmonella* ($P = 0.0206$) between the meat types, with turkey the most often contaminated, followed by chicken (Table 6). For stores A, B and E, there was no significant difference in recovery of all the microorganisms between the different meat types. No *Salmonella* was recovered from beef and pork from any of the retail outlets.

Salmonella Serotypes and *Campylobacter* Species Isolated

Thirteen *Salmonella* isolates recovered from the meat samples were confirmed by NVSL to belong to eight different *Salmonella enterica* serotypes (Table 7). The predominant serotype was *S. enterica* serotype Heidelberg

TABLE 7.
SALMONELLA ENTERICA SEROTYPES AND *CAMPYLOBACTER* SPECIES RECOVERED FROM RETAIL MEATS IN THE FARGO, NORTH DAKOTA METROPOLITAN AREA, 2005

Organism	*n* (%)	Chicken	Turkey
Salmonella serotypes			
S. Heidelberg	4 (30.8)	0	4
S. Kentucky	2 (15.4)	2	0
S. Typhimurium (Copenhagen)	1 (7.7)	1	0
S. Typhimurium	1 (7.7)	0	1
S. Blockley	1 (7.7)	1	0
S. Newport	1 (7.7)	0	1
S. Saintpaul	1 (7.7)	0	1
S. Senftenberg	1 (7.7)	0	1
Unknown	1 (7.7)	1	0
Total	13 (100)	5	8
Campylobacter species			
C. jejuni	10 (83)	9	1
C. coli	2 (17)	2	0
Total	12 (100)	11	1

recovered from turkey from which *S*. Typhimurium, *S*. Newport, *S*. Saintpaul and *S*. Senftenberg were also recovered. *S*. Kentucky, *S*. Typhimurium var Copenhagen, *S*. Blockley, and one undetermined serotype were recovered from chicken. *Campylobacter* isolates ($n = 12$) were speciated by the NADC. The predominant species was *Campylobacter jejuni* recovered mainly from chicken (9/10), with only one recovered from turkey; *C. coli* was only recovered from chicken.

DISCUSSION

A wide range of retail meat products (turkey, chicken pork and beef) were sampled in this study. Overall, there was a significant difference in contamination rates of *Campylobacter* and *Salmonella* from the different meat types, with most *Campylobacter* and *Salmonella* recovered from chicken and turkey products, respectively, and none from pork and beef. Consumption of undercooked poultry is a major risk factor for human campylobacteriosis (Pezzotti *et al.* 2003). Raw poultry meats are commonly contaminated with *Campylobacter* with rates as high as 100% reported (Baker *et al.* 1987; Atanassova and Ring 1999).

The U.S. National Antimicrobial Resistance Monitoring System (NARMS) isolated *Campylobacter* on pork chops (0.4%), ground turkey (1.7%) and chicken breast (97.9%), but not ground beef (0%) (US-FDA 2004). The lower levels of *Campylobacter* in pork and beef may be due to a lower incidence of these organisms in swine and cattle than in poultry, as well as the sensitivity of *Campylobacter* to atmospheric oxygen and other environmental stresses during transport, processing and storage of meat (Zhao *et al.* 2001). In contrast to our results where no *Campylobacter* and *Salmonella* were recovered from pork, a nationwide study found that *Salmonella* (9.6%), *C. jejuni* (1.3%) and *C. coli* (1.3%) were recovered from 504 retail pork samples purchased from 24 stores in six cities in the United States (Duffy *et al.* 2001).

In our study, *Salmonella* prevalence was 3% (13/456) of all retail meat samples. The *Salmonella* contamination rate for chicken was 4.1% (5/123), which is strikingly similar to what Zhao *et al.* (2001) reported for grocery stores in the Washington, DC metropolitan area. In that study, *Salmonella* was isolated from 3.0% of the 825 meat samples, and chicken had a *Salmonella* contamination rate of 4.2%. In our limited study of five grocery stores in Fargo, North Dakota, we observed no significant difference in generic *E. coli* recovered from the four meat types. In contrast, Zhao *et al.* (2001) reported that chicken had the highest rate of generic *E. coli* contamination (38.7%), and that beef (19.0%) and pork (16.3%) were more likely contaminated with generic *E. coli* than turkey was (11.9%). The difference may have been due to the number of stores sampled (5 versus 58). Furthermore, the percentage of *Salmonella* recovered in the assorted turkey and chicken parts was similar to findings of the larger FoodNet study conducted in 2002–2003 (Zhao *et al.* 2006).

The stores sampled in our study were mainly regional chains whose meat supply was also regional. This might explain why we did not find a significant difference in recovery of the microorganisms among stores, even if some within store differences were observed between meat types. In contrast, Zhao *et al.* (2001) reported significant differences in store contamination rates of retail meats by *Campylobacter* but not for *Salmonella*, which may be attributed to multiple meat suppliers. The smaller number of stores in our study (5) compared with the study by Zhao *et al.* (2001) (58) could explain the difference in these results. Meat brand did not significantly influence recovery of microorganisms, possibly due to similar product batches within stores, the location of stores within one metropolitan area, limited number of stores sampled, short sampling interval in a single season and the relatively smaller number of samples tested.

Three of the *Salmonella* serotypes reported in this study (Heidelberg, Typhimurium and Kentucky) were among the major serotypes reported by the larger studies conducted by FoodNet and others (Zhao *et al.* 2001; CDC 2005,

2006). For example, in 2005, the *Salmonella* serotypes accounting for 56% of human infections included Typhimurium (20%), Enteritidis (15%), Newport (10%), Javiana (7%) and Heidelberg (5%) (CDC 2006).

Variation in the incidence of bacterial contamination may be attributed to differences in levels of contamination of specific food items and differences in food handling practices (CDC 1998). However, overall, the rates of microbial contamination of retail meats with generic *E. coli* in this study ranged from 61% for chicken breast samples to 88% for ground turkey samples, and were not statistically different as were the rates observed for *Campylobacter* and *Salmonella* contamination on poultry.

In conclusion, these data indicate that meat products, particularly poultry (chicken and turkey) purchased from retail stores in the Fargo metropolitan area, may occasionally be contaminated with *Campylobacter* and *Salmonella.* The contamination was dependent on the type of meat, with some retail meats contaminated with more than one foodborne bacterial pathogen. These data confirm that raw retail meats may be vehicles for transmitting foodborne diseases and signify the importance of sustained surveillance of foodborne pathogens in retail meats. In addition, the data suggest that microbial contamination on raw retail meats purchased in the metropolitan area of a rural agricultural state are not higher than those reported for larger urban locales.

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